Space Weather Technical Forecast

Issued on Friday, 24 March 2023 at 01:30 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Further Minor/Moderate Geomagnetic Storms expected with a chance of Moderate storms at first. Daily Slight Chance of R1/R2 Radio Blackouts.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: AR3256 in the southeast quadrant remains the largest and most complex region on the disc, with potentially a small delta spot, but despite this solar activity has been Low over the past 24 hours. AR3256 generated the largest flare of the period, which was only a C1.2 flare at 23/0130 UTC. After this there was a generally decreasing trend in x-ray activity, with the remaining four numbered sunspot regions all small, weak and magnetically stable.
No Earth directed CME's have been observed in available imagery.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 by DSCOVR and ACE, was initially reflective of gradual easing of a fast wind regime, likely to be that from CH85/+ given the predominantly positive phi angle (away from the Sun). This gave way to a CIR or CME-like rising density and IMF, with this new behaviour beginning from around 23/0600UTC. Currently the northeast-heading 20th March filament CME seems the most likely candidate for the resulting highly disturbed solar wind environment.

The solar wind was predominantly at slightly elevated levels, 440-490 km/s, but with brief peaks into elevated levels, the highest 513 km/s at 23/1411 UTC. The solar wind density was initially at average levels around 8ppcc, but from approximately 23/0600 UTC the density steadily increased to become well above average, peaking at 63 ppcc at 23/1347 UTC. The IMF was weak and steady until approximately 23/0600UTC, then gradually increased to reach strong levels, peaking at 22 nT at 23/1418 UT, then remaining at strong levels for the rest of the day. The north-south component became predominantly negative after approximately 23/0600 UTC, and mostly strongly negative from late afternoon, with -17nT being reached at 23/1736 UTC. The net result of the above solar wind measures was an increase from initially Quiet (Kp 2) levels of geomagnetic activity to G1/Minor Storm to G3/Moderate storm (Kp 5-7) from 23/0900 UTC, with the G3/Moderate storm levels at 23/1200-1500 and 2100-2400 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 is now at Background levels.

The high energy electron flux (greater than 2MeV) has diurnally fluctuated between Normal Background and Moderate levels, with peak flux of 315pfu at 23/0945UTC. The associated 24-hour Electron fluence remained below the Active (1e8 integrated pfu) threshold, with a steady then rapidly declining trend. At 24/0001UTC the observed fluence was 3.53e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Very Low or Low Solar activity is expected, with a daily slight chance of isolated Moderate flares, mainly from AR3256 or from one of several returning regions due onto the disc form the far-side in the period.

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Solar Wind / Geomagnetic Activity: There were previously two CMEs featuring in the forecast, and they may have combined to form the probable CME effects that are now occurring. Although the enhanced solar wind environment could be also the arrival of a CIR from CH86/- this is considered less likely. The combination of the residual CME effects and the arrival of a CIR and HSS from CH86/- will maintain enhanced geomagnetic activity through most of the forecast period,

Initial G2-G3 Moderate/Strong geomagnetic storm conditions (Kp 6-7) are expected, these gradually declining to Active to G1/Minor storm (Kp 4-5) conditions overnight and during tomorrow (25th), but with a chance of isolated G2/Moderate storm conditions due to the arrival of the HSS from CH86/-. From day 3 (26th) a gradual decline to Unsettled to Active (Kp 3-4) conditions is expected.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to continue close to Background, with only a Slight Chance of further enhancements should any significant flares occur.

The high energy (greater than 2 MeV) electron flux is expected to remain and Background to Moderate levels today and tomorrow, and then gradually increase Moderate to High levels from day 3 (26th) in response to the enhanced wind environment from CH86/-, after initially being suppressed by the enhanced geomagnetic activity. The associated 24-hour fluence is expected is also expected to rise from day 2 (25th), but remaining below the Active (1e8 integrated pfu) threshold.

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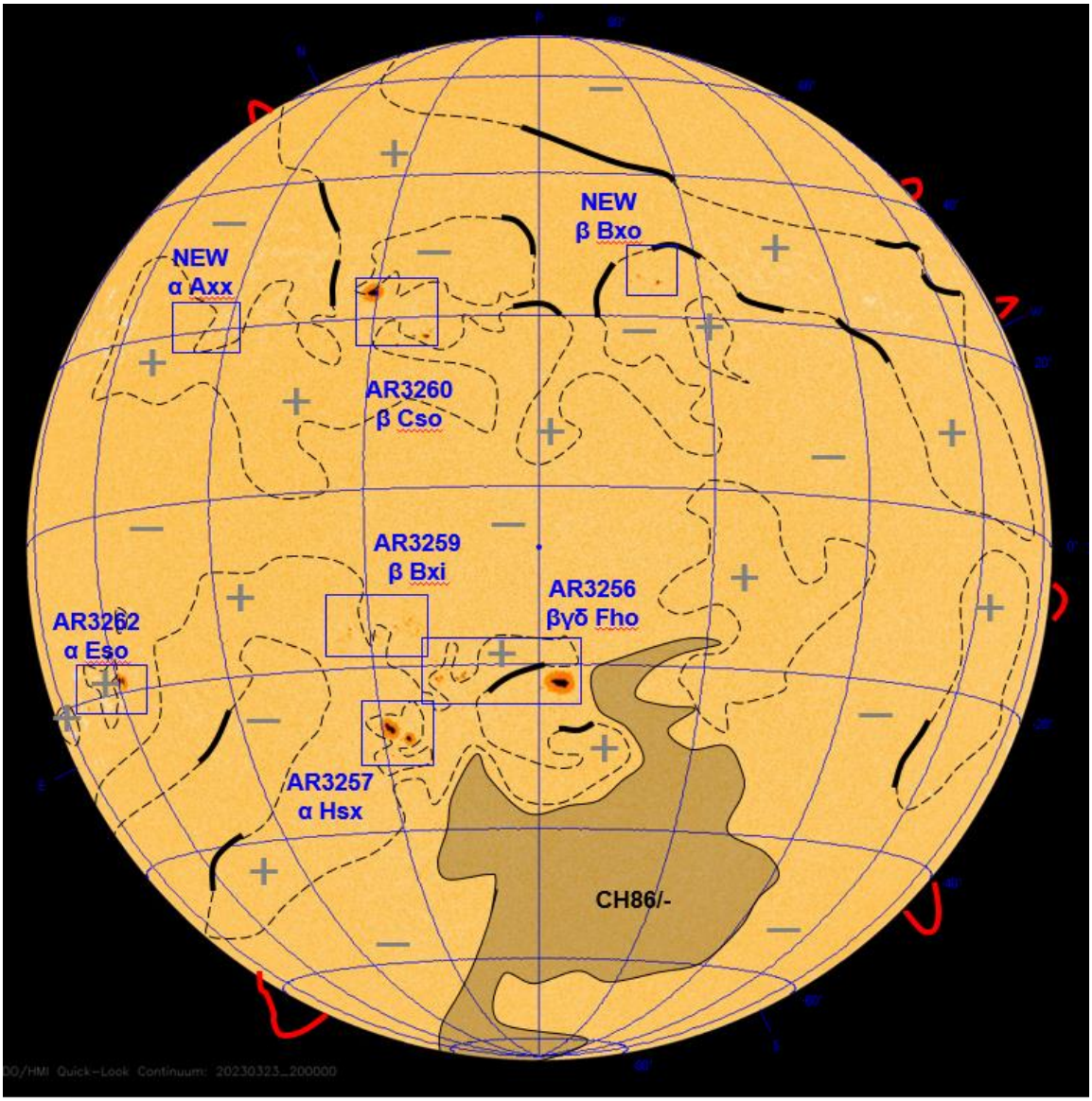
Figure 1. Solar Analysis Valid 23/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There were previously two CMEs featuring in the forecast, and they may have combined to form the probable CME effects that are now occurring. Although the enhanced solar wind environment could be also the arrival of a CIR from CH86/- this is considered less likely, as the Phi angle remains positive and also the Phi angle at Stereo-A only switched to becoming negative from approximately 23/1530 UTC, with STEREO-A approximately a day ahead of Earth. The CIR and then HSS are therefore still yet to arrive, and are expected today, with the CIR potentially being a significant event due to possible wind speeds of 600-650 km/s within the HSS. Also, CH86 is negative, which is likely to have a greater impact this close to the recent equinox. Therefore enhance geomagnetic activity is expected through much of the forecast period.

Initial G2-G3 Moderate/Strong geomagnetic storm conditions (Kp 6-7) are expected, these gradually declining to Active to G1/Minor storm (Kp 4-5) conditions overnight and during tomorrow (25th), but with a chance of isolated G2/Moderate storm conditions due to the arrival of the HSS from CH86/-. From day 3 (26th) a gradual decline to Unsettled to Active (Kp 3-4) conditions is expected.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	100	70	40	10
Strong	G3	Yes	80	30	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: Solar wind parameters for past 24 hours.

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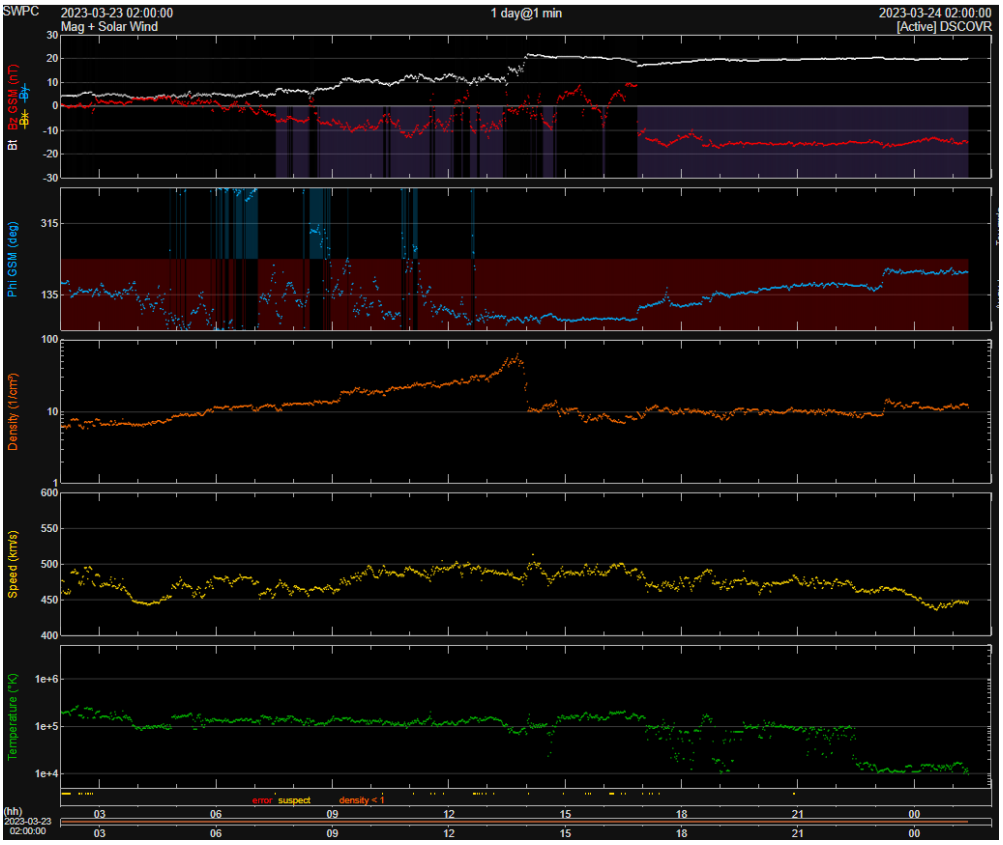

Radio Blackouts - X-Ray Flares:

Solar activity is most likely to be Very Low or Low through this period, but with a daily Slight Chance of rising to Moderate given the presence of AR3256 with potentially a small delta spot. However, the Carrington locations for up to three returning groups lie near the eastern solar horizon, and so the risk of significant flares may increase later in the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	10	10	10	10
Very Active	R3 to R5 X Class	No	1	1	1	1

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Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES16 has now returned to Background levels. Overall little change is expected, although there is a Slight Chance of future enhancements from one of the larger filaments should they erupt and any active regions which potentially rotate onto the visible disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux is expected to remain and Background to Moderate levels today and tomorrow, and then gradually increase Moderate to High levels from day 3 (26th) in response to the enhanced wind environment from CH86/-, after initially being suppressed by the enhanced geomagnetic activity. The associated 24-hour fluence is expected is also expected to rise from day 2 (25th), but remaining below the Active (1e8 integrated pfu) threshold.

MOSWOC REFM is considered to be offering reasonable guidance, in keeping the fluence below the Active threshold for days 1 to 3.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	20	30	50
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 3: Met Office REFM

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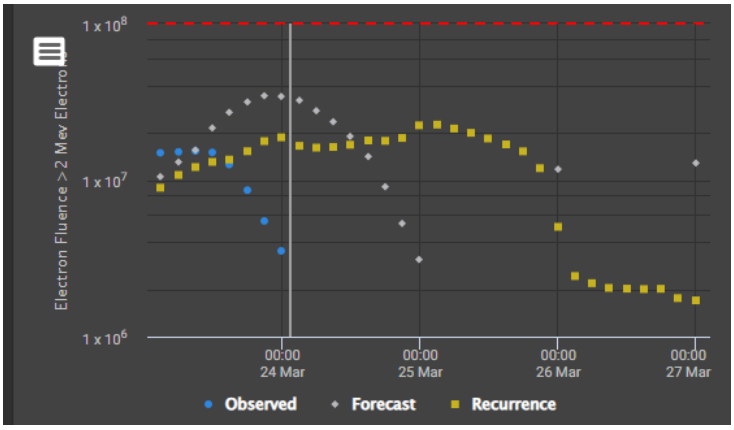

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